TECHNICAL REPORT

AST_TB_heaters_design_A01.doc
Date: 7th March 2006

Laboratory for the study of radiation effect on space materials
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Reference	Content
AST Thermo balance test: heaters design	Description of method of heaters design

signature

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date	change description	revision
02/03/06	First emission	

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NATURE OF THE PROBLEM

The Thermal Balance test is one of the tests that will be performed on the AST during the qualification campaign. The thermal model has two different points where the temperature is fixed: one that simulate the contact of AST with AMS_02 Si Tracker and one that simulate the control with the TTCS.

PROBLEM RESOLUTION

In TBtest heat exchange of AST is performed via radiation to the shroud and via conduction through the fixture to the coldplate. There are two kinds of conductive interface that have to be controlled during this test: the I/F with the Si Tracker and the I/F with the TTCS.

- *Tracker I/F*
  The AST in test configuration is fixed by an Al fixture to the TV Chamber coldplate. The lower face of the fixture is in contact with the surface of the cold plate. The TBF will provide the thermal environment given during flight by the mechanical connection to the AMS_02 Si Tracker. To achieve the desired temperature on Tracker I/F two test resistive heaters (in blue on figure 1) and two platinum resistance thermometer (PRT) PT100 will be installed on the TBF (one heater and one PRT for each plate of the fixture) to control and monitor temperature variations during test. The control of temperature will be implemented with a two-channel temperature controller used to guarantee the same temperature on each plate of the fixture.
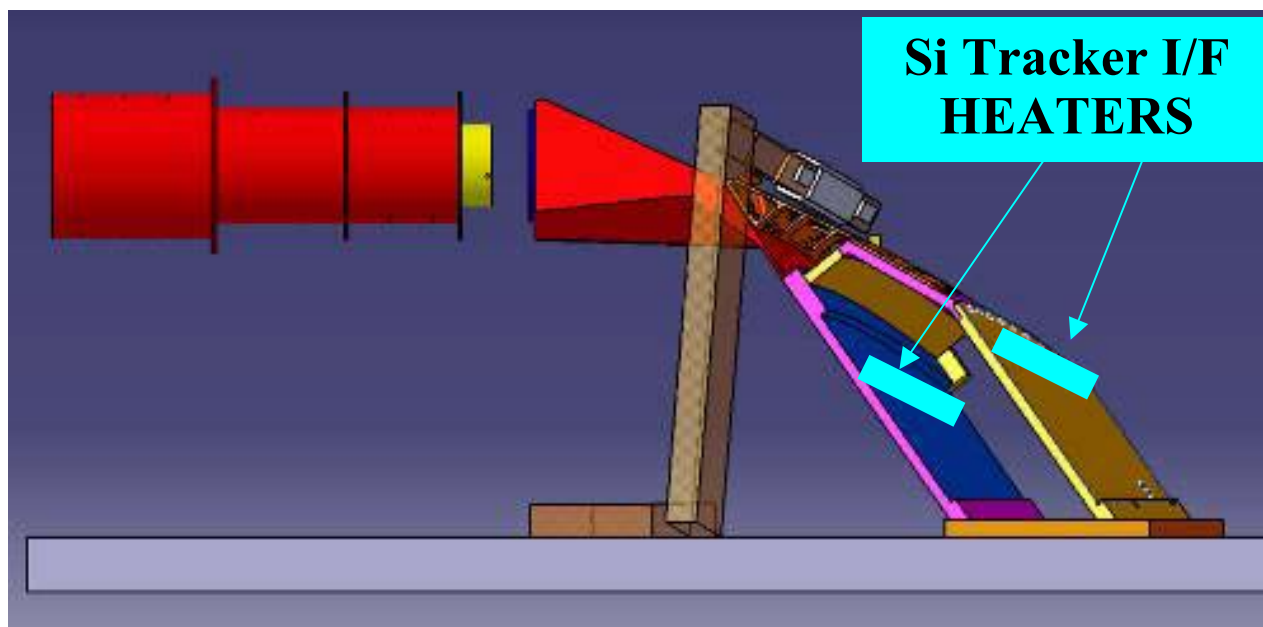
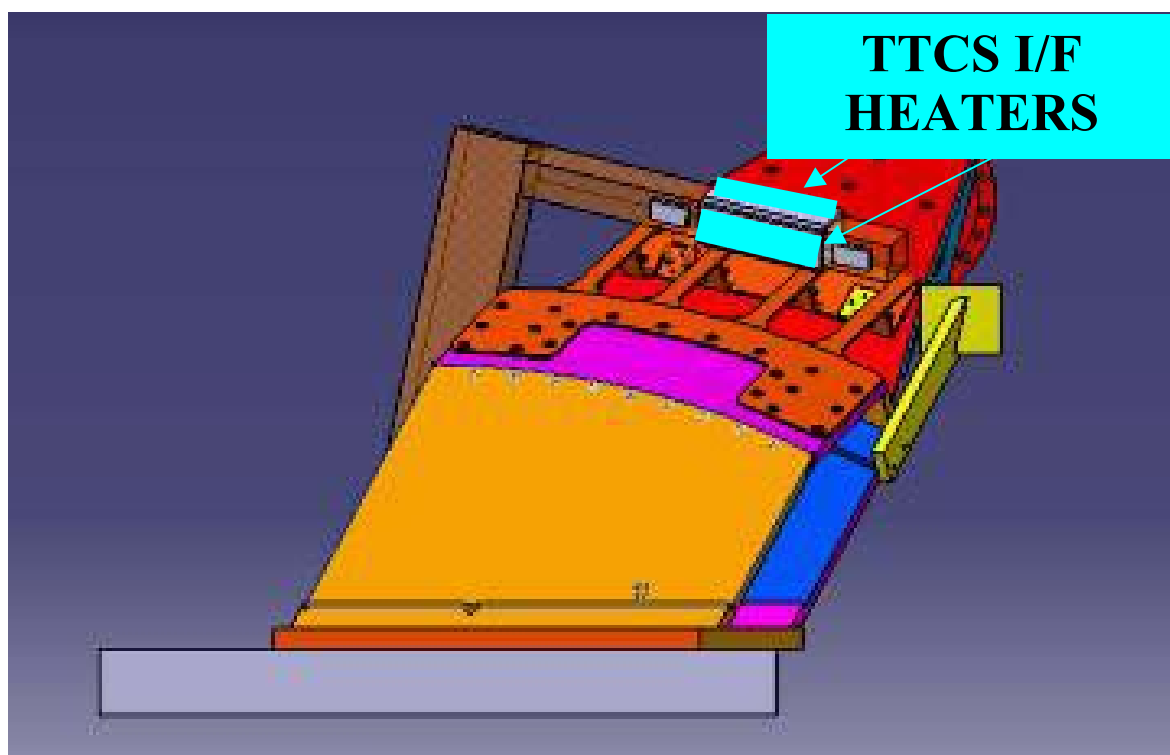**Figure 1 : heater position on Tracker I/F**

Figure 2 : heater position on TTCS I/F

- *TTCS I/F*

   The conductive connection between Star Tracker Active Thermal Control System and the AMS_02 TTCS will be simulated by connecting the two copper blocks, housed at the base of the Star Tracker by two copper braids to a Cu arm attached to the cold plate. The Cu arm will be equipped with four heater controlled by a PRT placed on the TTCS blocks (in blue on figure 2, replicated on opposite sides of the arm but not visible).
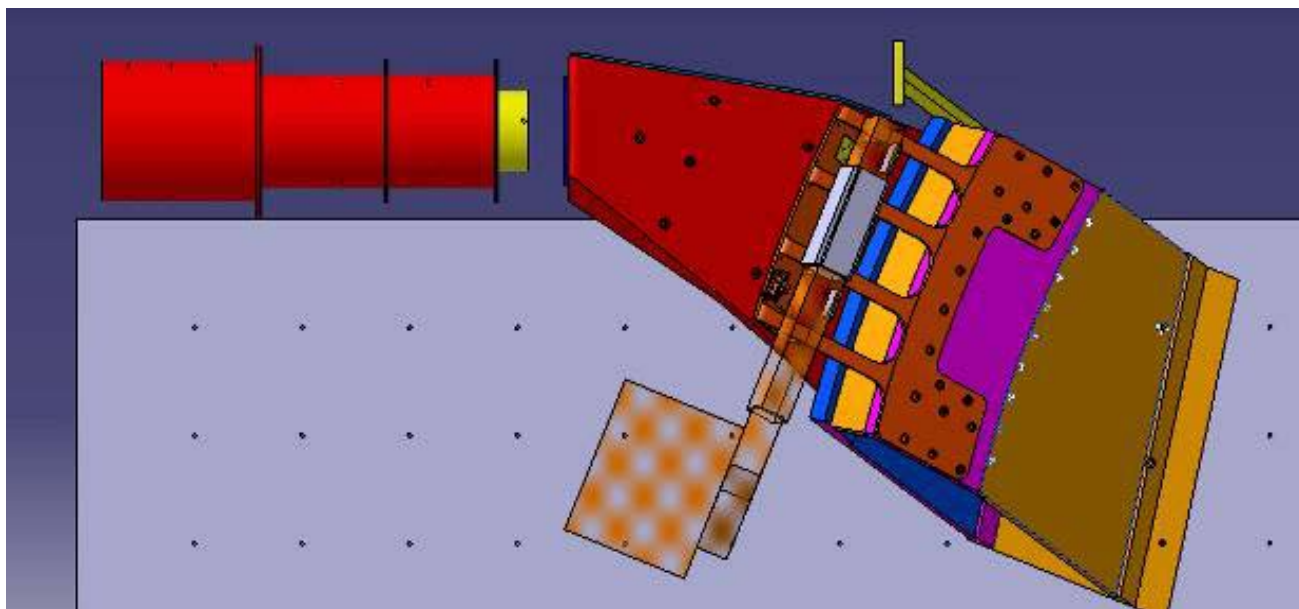

Figure 3 : view from the top

HEATER DESIGN

Worst case hot

The target is that the temperature needed for the Tracker I/F is 28°C and for the TTCS is 15°C.

- *TTCS I/F*

   When the test starts, all is at room temperature (about 20°C). So in the transient we need to cool the TTCS I/F to obtain 15°C on this point and also to dissipate the 3.8 W coming from the AST CCD and from the electronic board. So the target is to design a copper arm capable to extract more than 4 W (to be conservative we assume 18 W) from the TTCS I/F to the coldplate (that in this phase acts like a heat sink). In transient we can assume a coldplate temperature of 5°C to achieve this target because we can't go too down with temperature, because while we need to cool the TTCS I/F, we need also to heat the Tracker I/F to reach 28°C: this is thermal connected with the coldplate and if we go too down with temperature, we need too power to the Tracker I/F heaters. So we dimensioned the section and the length of this bar to achieve 18 W of dissipation from TTCS I/F when this is at 15°C (the target temperature of TTCS I/F in worst case hot) and the coldplate is at 5°C.

   When the system is at the equilibrium, only 3.8 W pass into this blocks, then the coldplate can be fixed at 11°C. During this case, the heaters on the Cu arm are used to have a fine control of the temperature but few power will be needed to maintain the equilibrium, so the power requested by the TTCS I/F heaters is not important in this phase.

- *Tracker I/F*

   When the test starts, all is at room temperature (about 20°C). So in the transient we need to heat the Tracker I/F to obtain 28°C on this point. So the target is to estimate the power for the heaters. We assumed before a coldplate temperature of 5°C, so considering the section and the length of the Tracker I/F we calculated the power dissipated from the Tracker I/F (at 28°C) to the coldplate (at 5°C). The result was about 130 W, so to be conservative, we suppose a multiplying coefficient of 2.5, we obtain 325 W: we considered two heaters (one on each of the two Al plate of the fixture, see Figure 1).

   Then we selected an heater capable of more than 180 W at 220 V, with standard dimension (fast availability). We selected two heaters of 1 x 10 inch (everyone of these matches the dimensions of each side of the TBF) from MINCO stock heaters catalog: HK5167R264.0L12A.

Worst case cold

The target is that the temperature needed for the Tracker I/F is -10°C and for the TTCS is -5°C.

- *Tracker I/F*

  From the temperature reached on worst case hot, it is necessary to cool the Tracker I/F from 28°C to -10°C, so in the transient we assume to set the coldplate at -20°C: when the tracker is at 28°C and the coldplate is at -20°C, 280 W are dissipated from the Tracker I/F to the coldplate; when the tracker is at -10°C and the coldplate is at -20°C, 60 W are dissipated from the Tracker I/F to the coldplate.

  When the system is at the equilibrium there is no thermal flux from the Tracker I/F to the coldplate and this can be set at -10°C. During this case, the heater is used to have a fine control of the temperature and few power will be needed to maintain the equilibrium.

- *TTCS I/F*

  From the temperature reached on worst case hot, it is necessary to cool the TTCS I/F from 15°C to -5°C. In the first phase of the transient and we give not power to the heaters and we set the coldplate at -20°C, so at least 60 W are dissipated by the Cu arm connected at TTCS I/F.

  In the second phase of the transient we set the thermostat of the heaters of TTCS I/F at -5°C and the coldplate at -20°C, so at least 26 W are dissipated by the Cu arm connected at TTCS I/F. So we need 22 W (4W is dissipated by the electronic board and the CCD of the AST) to heat the TTCS I/F to stabilize its temperature at -5°C while the coldplate is at -20°C. To be conservative, we suppose a multiplying coefficient of 2.5, we obtain 65 W. Then we selected an heater capable of more than 65 W at 30 V, with standard dimension (fast availability). We selected four heaters of 1 x 3 inch (everyone of these can be placed on the Cu blocks between the copper braids and the coldplate) from MINCO stock heaters catalog: HK5165R52.3L12.

  When the system is at the equilibrium the coldplate is at -10°C. In this case the power dissipated from the TTCS I/F to the coldplate is 9 W.